Collaborative Decision Making: Complementary Developments of a Model and an Architecture as a Tool Support

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ABSTRACT. Recent years we can hear a lot about cooperative decision-making, group or collaborative decision-making. These types of decisions are the consequences of developed working conditions: geographical dispersion, team working, and concurrent working.

In the paper we present two research works concerning two different collective decision situations: face-to-face decision-making and synchronous distributed decision-making. These two research studies adopt different approaches in order to support decision-making process, in view to different research objectives. Nevertheless, the conclusions show complementary aspect of these two studies.

KEYWORDS: DSS, Cooperative DSS, Collaborative Decision Making

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Introduction

As underligned by Sankaran and Bui (2008), organizations routinely make decisions that require consultations with multiple participants.Combining all points of view towards a consensus acceptable to all parties is always a challenge. Negotiation and collaborative processes become then a strengthen point for organisations. Modern negotiation theory that finds its roots in decision theory and game theory focuses on interactive processes among antagonists with the attempt to reach compromises. In order to achieve this objective they propose an organisational model for transitional negotiations.

On an another point of view,, cooperative or collaborative decision-making is a more and more complex and process that is predominant in organisations. It has been already noticed in the research literature, a displacement from individual decision-making to collective decision-making (Shim, Warkentin *et al.* 2002). These types of decisions are the consequences of developed working conditions: geographical dispersion, team working, concurrent working, etc.

Pascale Zaraté and Jean-Luc Soubie (2004) develop a matrix of collective decisions taking into account two principal criteria: time and place (see **Table 1**). In their work, they also give an overview of several supports and their correspondence with different types of collective decision-making.

We then can find different types of collective decision-making process:

	Same time	Different times
Same place	Face to face decision making	Asynchronous decision making
Different places	Distributed synchronous decision making	Distributed asynchronous decision making

TABLE 1. **COLLECTIVE DECISION MAKING SITUATIONS**

We define each kind of collective decision making situation:

1) Face to face decision making: different decision makers are implied in the decisional process and meet them around a table. This is a very classical situation;
2) Distributed synchronous decision making: different decision makers are implied in the decisional process and are not located in the same room but work together at the same time. This kind of situation is known enough and is common in organizations;
3) Asynchronous decision making: different decision makers are implied in the decisional process and they come in a specific room to make decisions but not at the same time. The specific room could play a role of memory for the whole process and also a virtual meeting point. This kind of situation is well known in the Computer Supported Collaborative Work (CSCW) field and some real cases correspond to it, but for decision making it has no intrinsic meaning for a physical point of view, we cannot imagine decision made in organisation in this way: it is the reason why this case has a grey background in **Table 1**. For us this case could be assimilated to the next situation. Nevertheless, for a mediated communication point of view we have to check what are the impacts induced by this particular situation and this case could be seen as a virtual room well known in the GDSS field.
4) Distributed asynchronous decision making: different decision makers are implied in the decisional process and they do not necessarily work together at the same time and in the same place; each of them have a contribution to the whole decisional process.

In this paper, we will present the complementary aspects of two research studies concerning two different decision situations of collective decision-making: a conceptual model development and architecture of a tool support system for Cooperative Decision Making Processes. The model corresponds to the first decision situation explained in the previous paragraph, that is face-to-face decision-making and is exposed in the §2 of this paper. The second is a proposition of architecture or platform for cooperative decisions in generally. This research concerns the third decision situation, distributed synchronous decision-making. This tool architecture is exposed in the §3 of this paper. The fourth part contains a comparative study of these two researches and points out their complementary aspect.

Conceptual Model of Collaborative Decision Making

If we consider the matrix presented on the **Table 1**, the collaborative decision-making process in a synchronous way is a very rich way of decision making on an information and opinion exchange point of view for big and complex projects like vehicle development projects. Nevertheless, this type of decision-making has many difficulties like conflict management, different preferences of decision makers, information retrieval, and different objectives in the process (Jankovic, Bocquet *et al.* 2006).

The recent growing evolution of the e-negotiation domain shows that the previously described situations are more and more common. This lead to new kind of systems supporting negotiations in an electronic way of communication the Group Decision Negotiation Support Systems (see for example Sankaran and Bui (2008)).

The field research showed that this is the most frequent decision-making type when it comes to development projects. The first phase of development project, i.e. New Product and Process Development (NPPD), is a special phase, because it is a collaborative decision-making phase. One of our research objectives was to develop a support in view to help project team in this process. In this purpose we have developed a conceptual model of collaborative decision-making. This model was used to model collaborative decisions identified in the first phase in PSA Peugeot Citroën: 73 identified decisions.

Further in this part of the paper, in § 2.1, we give a description of the first phase of NPPD process. In § 2.2 we explain the specificities of the decision-making in development project as well as the difficulties created by the project complexity. Afterwards, in the §2.3, we present globally the developed conceptual model and its application.

Industrial Context: Project Definition Phase

New Product and Process Development (NPPD) is one of the key processes contributing to enterprise success and future development (Marxt and Hacklin 2004). Identification of client needs during the market research phase represents a starting point for a Project Definition phase. In PSA Peugeot Citroen, the Project Definition phase is the first phase of NPPD cycle. This phase is characterised by numerous relationships between different actors contributing to the NPPD process and a considerable uncertainty issues to be dealt with.

The Project Definition phase is the first phase of NPPD process. The project success emanate from this phase (Morris 1988). This phase is also a collaborative decision-making phase. The most of strategic decisions are made within this phase. Whelton, Ballard et al. (2002) have conducted a research on the importance of this phase and found that almost 80% of the product and process are specified in this phase. The decision-making is also an engagement of enterprise resources, and therefore it implies the importance of this phase globally for one project.

The Project Definition phase is very complex because:

– It is a phase where all aspects of one project are to be defined,

– Project organisation and management are set up throughout the fulfilment of functions assigned to every project team member,

– It is a phase of convergence of project objectives through collaborative decision-making process,

– Management bases as well as motivation of project team are built up progressively throughout this phase.

At the very beginning of this phase, different enterprise departments give the global guidelines for the definition of project objectives to the project team. Some of these departments are marketing, production, innovation, and strategy. The given guidelines represent a transcription of strategic orientations of the enterprise, given by different fields. The project team has also to take into account the results of market segmentation and targeting as well as to integrate client needs (Jankovic, Bocquet *et al.* 2006)(**Figure 1**).

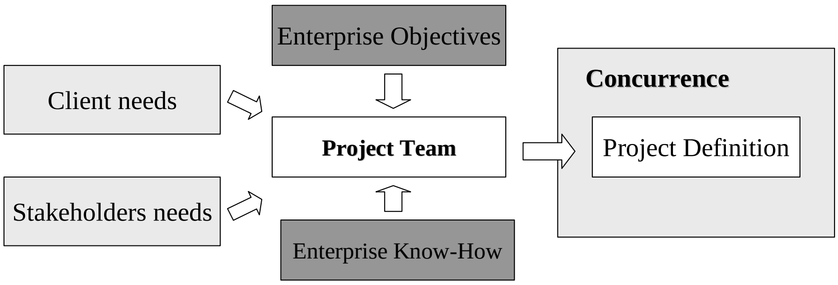

FIGURE 1. **PROJECT OBJECTIVES DEFINITION CONTEXT**

The mission of the project team is to decompose global orientation given by enterprise on objectives of sub-systems, based upon systems engineering methodology, to discern their global incoherence and propose the adequate solutions. This feasibility study is done also with the help of different knowledge poles, experts for different domains. Project objectives definition is obtained in the balance point between enterprise knowledge and enterprise ambitions, i.e. strategic orientations. This is a negotiation and collaboration process, where project team is progressively converging to project objectives definition.

One of the difficulties of this phase is that there are over 150 objectives to monitor on the global level. Correlations between these objectives are not often determined, so there is no certainty in how the changes of one objective will influence the other. Furthermore, the Project Definition phase is crucial for innovation introduction. In this phase, project team has to decide what are the innovations to be incorporated in the vehicle development. This innovation introduction increases even more the difficulty of identification of possible correlations between project objectives.

Collaborative Decision Making in the Fist phase: Complexity and Problems

Vehicle development project are complex projects (Baccarini 1996). The difficulties in the project induced by its complexity can be several: project objectives and goals defining (Morris and Hough 1987), project planning, coordination and control requirements (Baccarini 1996; Bubshait and Selen 1992; Melles, Robers *et al.* 1990)

Project management methodology's starting point is clearly defined project objectives and it represents a base for further development of different approaches used in project management (quality management, economic optimisation, risk management). This is clearly opposite to the Project Definition phase needs. During this phase, project team defines project objectives and therefore the existing approaches and methodologies are hardly implemented. Louafa (2004) also confirms that the project characteristics, like the ones we exposed related to the first phase accentuate the limits of existing project management methodology.

The upper stated problems of project planning, organisation and coordination within this phase aggravate the project control. Only existing control within this phase was possible at the very end of it, and on the upper management level, i.e. Senior Directors company level. During this phase, the project manager does not have any insight in the global project progress related to convergence and coherence of project objectives and thus the possibility to introduce the correction activities (Jankovic, Bocquet *et al.* 2006). The control point was at the end of this phase where project team obtains a "go or no go" decision from the top management. In the case of "no go" decision the deadline for the vehicle development is automatically increased. This augmentation can be up to several months. This additional delay is not acceptable in current conditions where a global course for time reduction is ongoing. There is another danger concerning the control problems. The Project Definition phase influence and determines the project success. If there is no control of validity of project objectives, the whole project is at stake.

The whole first phase in PSA Peugeot Citroen is collaborative decision-making phase. Collaborative decision-making is a collective decision-making where different actors have different and often conflictual objectives in decision-making process. Decision-making actors in the Project Definition phase are experts in different domains having different information and knowledge concerning the problem. Therefore their vision of the problem is "coloured" by their knowledge and aspects that they are concerned with. The fact that every decision makers has different objectives implies also that they have different priorities concerning the decision values and alternatives. Hence, the collaborative decision-making represents a rich way for decision alternatives generation and helps project team in the identification of decision impacts. The problems related to collaborative decision-making and project management concern several levels (Jankovic, Bocquet *et al.* 2006):

– Collaborative decision level: The problem of identifying appropriate information about important decision elements. For example: who are the actors in the collaborative decisions, what are the information that the decision makers need to have in the moment of decision making, what is the level of criticality of information needed, what causes the conflicts in collaborative decisions, etc.

– Collaborative decision-making process level: The difficulty of determination of the influence of collaborative decisions on different activities or decisions further in the Project Definition phase. For example: what are the decisions to be made before and after, what are the decisions that will be influenced by the present collaborative decision, i.e. what project objectives will be influenced, what are the activities influenced by this collaborative decision, etc.

– Project level: The difficulties to implement the existing project management methods and tools in the management of this phase. For example: the base of project management is to identify activities constituting a phase in new product development determined by the project team in accordance with project goals. The problem is that the project objectives are not defined and in this phase, project complexity does not facilitate identification of activities.

Collaborative Decision Making Model and Its Application

Our research on collaborative decision-making is upheld by the field research done in collaboration with PSA Peugeot Citroen. In view to specific context of collaborative decision-making in development projects, the objectives of our research were double:

– To help decision-makers, in this case the project team, in collaborative decision-making process,

– To help the project team in managing the project.

Therefore we have developed a conceptual model of collaborative decision-making. The aim of this model is to identify and define the intrinsic information and elements necessary for a good quality decision-making. This model represents a result corresponding to decision support objective. It is also a base of project management tool we have developed. This tool will not be detailed in this paper.

The conceptual collaborative decision- making model is developed upon the systems theory of Le Moigne (1990). If we consider the systems theory, in collaborative decision-making decisional system is common for two or more operational systems. This can be represented as on the **Figure 2**. The decision that is taken concerns a joint field of these two processes.

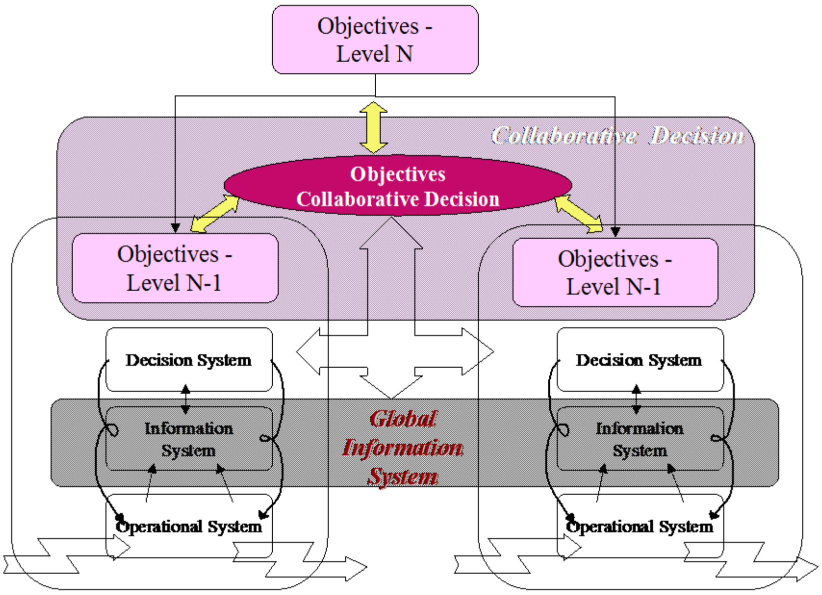

FIGURE 2. ***COLLABORATIVE DECISION-MAKING***

Le Moigne (1990) defines the concept of General System as a representation of an active phenomenon comprehended as identifiable by his project in an active environment, in which he functions and transforms teleologically. Therefore we have developed four different views in collaborative decision-making model: Objectives View, Process View, Transformation View and Environment View (see Figure 3). These views are interdependent and are not to be taken separately.

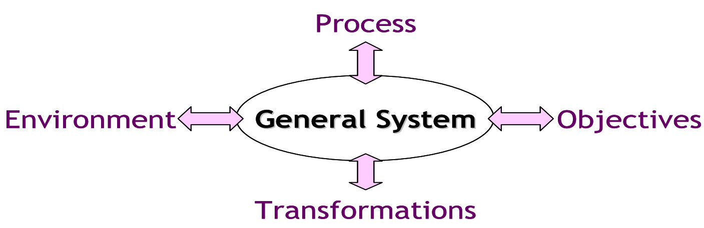

FIGURE 3. FOUR DIFFERENT VIEWS OF MODEL

Objectives View concerns objectives in collaborative decision-making. This view takes into account different objectives influencing this process, as well as their relationships. The collaborative decision-making objectives are also influenced by actors' preferences.

Environment is a complex surrounding system, living and non-living, having multiple relationships with the observed object and thus influencing object's behaviour. Three different environments influence collaborative decisions in New Product and Process Development: Decision environment, Project environment and Enterprise environment. Each of these environments is identified by his context, determining the influencing factors of collaborative decision-making and different actors relevant for collaborative decision-making. Therefore, Decision Environment is identified by decision-making context and actors participating in the collaborative decision-making process. This environment is influences by Project Environment, equally defined by Project Context and Project Influence Groups. Project and Decision Environment are influenced by Enterprise Environment, identified by its context and actors.

Process View represents the process of collaborative decision-making. Collaborative decision-making is a complex human-interaction and human-cognition process. Therefore, we have identified 3 general phases of collaborative decision-making process: Identification of the need for decision-making, Decision-making phase and Implementation and Evaluation. In the model we underline that every process implies the utilisation of the resources, human or material. Collaborative decision-making process is mostly human process. Nevertheless, sometimes in order to make a decision, it is required to use a digital mock-up or just a mock-up. These resources have to be planed also.

Transformation is a change performed on information and can be spatial (transfer of information) or form (transformation of the information into new information). These transformations can be grouped in two groups: preparatory transformations and implementing transformations.

Preparatory transformations are transformations that are required in order to dispose with elements necessary to decide upon. Implementing transformations are transformation in view to implementation of the decided solution.

A Decision Support Framework for Cooperative Decisions

In her work, Zaraté (2005) proposes a Cooperative Decision Support framework. It is composed by several packages:

- An interpersonal communication management system,
- A task management system,
- A knowledge management tool,
- A dynamical man/machine interactions management tool.

This framework is described in the figure 3.

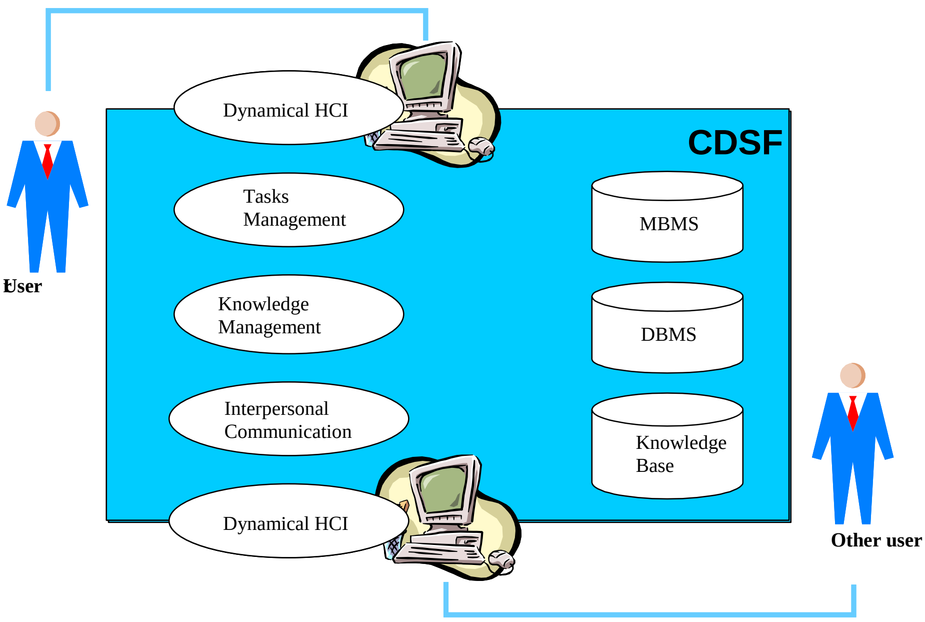

FIGURE 4. **COOPERATIVE DECISION SUPPORT FRAMEWORK ARCHITECTURE**

The interpersonal communication management tool must be able as in every kind of CSCW tool, to help users and decision-makers to very easily interact among themselves.

The dynamical man/machine interactions management tool must guide the users in their processes of solving problems in order to solve the misunderstanding problems.

The knowledge management tool must storage the previous decision made by the group or by other groups. The system must propose solutions or part of solutions to the group in very similar situations. In the case of a different situation the system must be able to propose the solution the most appropriated and the users could accept it or not. This tool is based on a knowledge management tool and based reasoning tools.

The part of the system for which the development is deeper, is the task management system. This tool has for objective to propose solutions or part of solutions to users. It calculates the scheduling of tasks and sub-tasks and each role that are assigned to each tasks. It also proposes an assignment of tasks to users or to the system itself. This tool is based on a Cooperative Knowledge Based System developed at the IRIT laboratory. This Cooperative Knowledge Based Architecture is based on libraries of models: users' models, domain models (or problems models) and contextual models. The calculation of the proposed solutions is based on several techniques: planning tools (for more details see (Camilleri 2000)), linear programming (see (Dargam, Gachet *et al.* 2004)). The main usage principle of this kind of tool is based on the interaction between the system and the users. The system proposes a solution to the group, the group takes in charge some tasks and then the system recalculates a new solution and proposes the new one to the group and etc. The problem or the decision to made is solved steps by steps each actors (system and users) solving parts of the problem.

Complementary Study of Model and Decision Support Framework

Our idea is to compare the developed model of collaborative decision making process with the proposed framework in order to find lack of representations.

Communication tools are very important for cooperative decisions, but also for collaborative ones. Event though these tools are not participating in the actual process of collaborative decision-making, they are indispensable before and after decision-making process. That is, we consider that these tools participate in expanded collaborative decision-making process.

Task management tools support task management and control by task definition and their assignment to different actors in the process. These tools fully support collaborative decision-making and are very important for the companies. These tools could be implemented through Operational Research tools as optimisation for example or also through Artificial Intelligence tools as for example planning tools. The main idea of these tools is to propose a plan of actions or tasks to decision makers. As we see it, they are very adapted for the Transformations View of collaborative decision-making model. Transformations View contains information of tasks before and after decision-making, deliverables necessary for good decision-making and important in the implementation, responsibility assignments, etc. Nowadays, it is not just necessary to optimise decision-making, but also to manage and control the realisation of what was decided.

Collaborative decisions are very complex because of existence of multitude of objectives, influence of different environments, participation of different actors, etc. Knowledge management tools have real utility in this process and can support Objectives and Environment Views.

In Objectives View, it is very important to know what are the different objectives in collaborative decision-making processes and their relationships. In this kind of decision-making, decision makers do not have the same objectives (Jankovic, Bocquet *et al.* 2006). It is important to have all these information in order to manage this process and its inevitable conflicts.

Information in the Environment View relate to different contexts influencing decision-making, as well as different actors and their roles in the decision-making process.

All these information are essential for good and quality decision-making. Some projects and their contexts are very similar, so examination of previous experiences can be very helpful.

The Interaction Human/Machine tool constitutes the last module of the architecture proposed by Zaraté (2005) and is very specific to computer science.

As we exposed in this part, almost part of our conceptual model could be supported by the proposed framework. There are also parts that are not directly correlating because of the very nature of collaborative decisions. For example, collaborative decision-making process is mostly done in the scope of face-to-face relationships, so there is no need to develop a support for this part of model. Nevertheless, we could imagine a support for decision structuring due to complexity of collaborative decisions (for example structuring of different elements of one decision, decomposition of the problem in order to have a better insight, etc.). Besides these elements, there are model parts like decision maker's preferences or Groups of Influences in the company, appertaining to the domain of human relations that rest easy to implement in some developed tools as Team Expert Choice for example (ref Tean Expert Choice) but difficult to maintain during the whole collaborative decisional process.

Conclusions

In this paper we have exposed a comparative study of two research works related to two different decision-making situations: collaborative decision-making, i.e. face-to-face and cooperative decision-making or distributed synchronous decision-making. Even though these two studies do not have the same results (because they have different objectives), a comparative study has pointed out several complementary elements. The main conclusions of this work are the following:

- Collaborative Decision Making is no more seen as a fact but as processes,
- Even though these two decision types concern two different decision situation, in general collective decisions show the same needs in terms of operational support,
- In order to support these processes in a better manner Tasks Management tools and Knowledge Management tools are necessary.

The next step of this work will consist in defining a global conceptual model for collaborative decision-making including the functionalities proposed by the cooperative decision support framework. This global conceptual model will be the basis of the Data Base Management tool defined in the CDSF. The main objective of our wok is to define a tool for collaborative decision making processes generic enough for supporting any kind of situations (see Table 1).

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